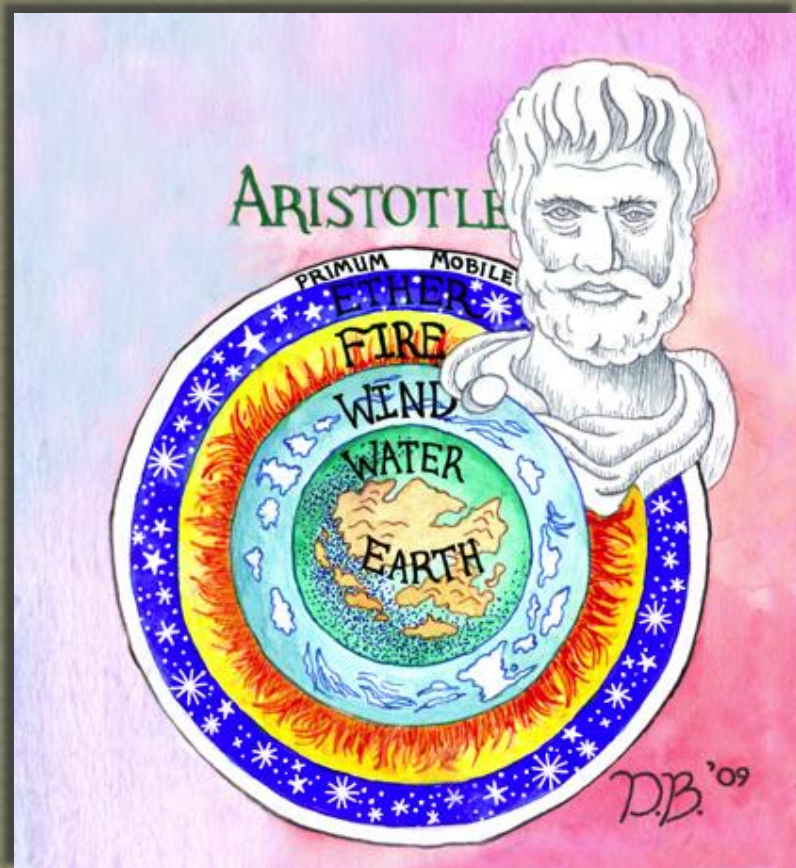


Theories of Matter in Greek Philosophy



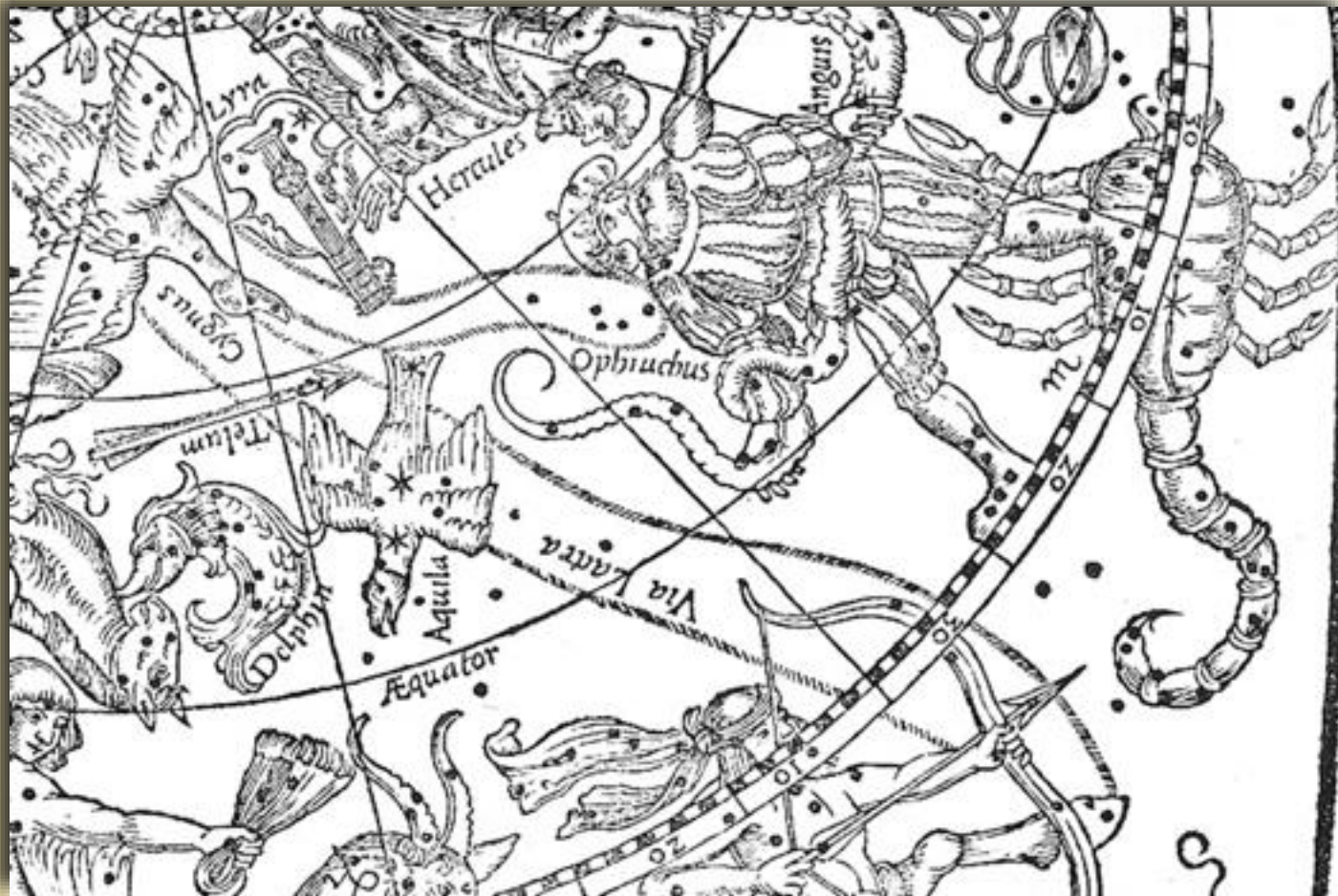
The History of Chemistry,
Part I

Before 600 B.C.

- Nature was unpredictable
- Fate was determined by capricious gods
- Truth was dogma handed down by priests



Variation and Constancy



- Some things appear to be permanent (mountains)
- Some things appear to constantly change (clouds)
- Other things are cyclic: constant change within permanent patterns (stars, seasons, night and day)

The Search for the Ideal: What Should Be

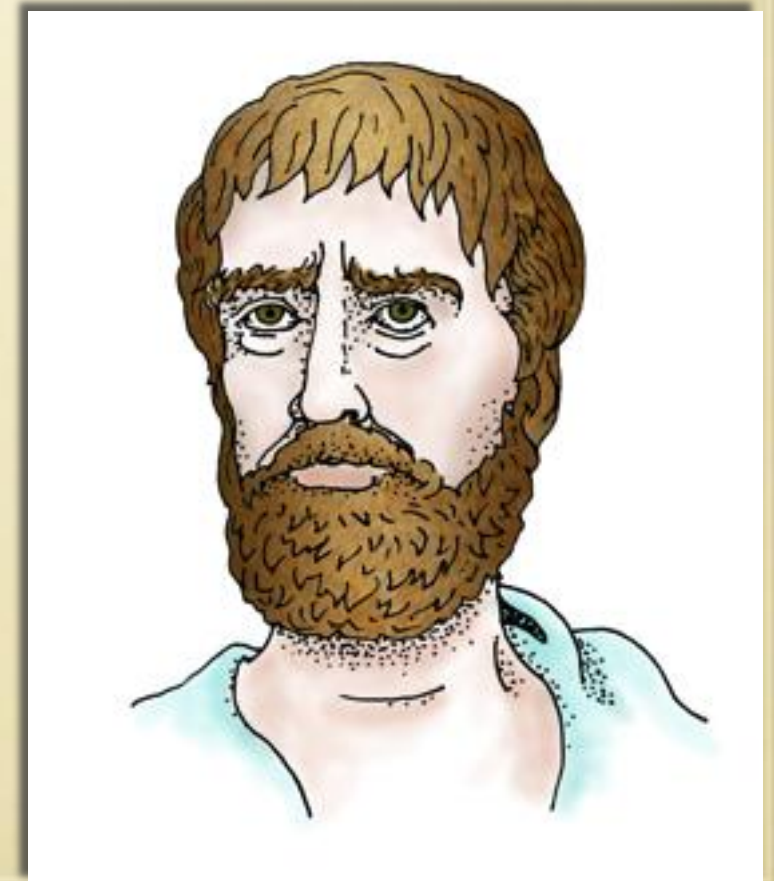
- The Perfect Forms of things
- The Sources of Truth
(can we trust our senses?)
- The Nature of Change
- The Fundamental
Material(s)
- Plato's Allegory of the Cave:
The World of Shadows



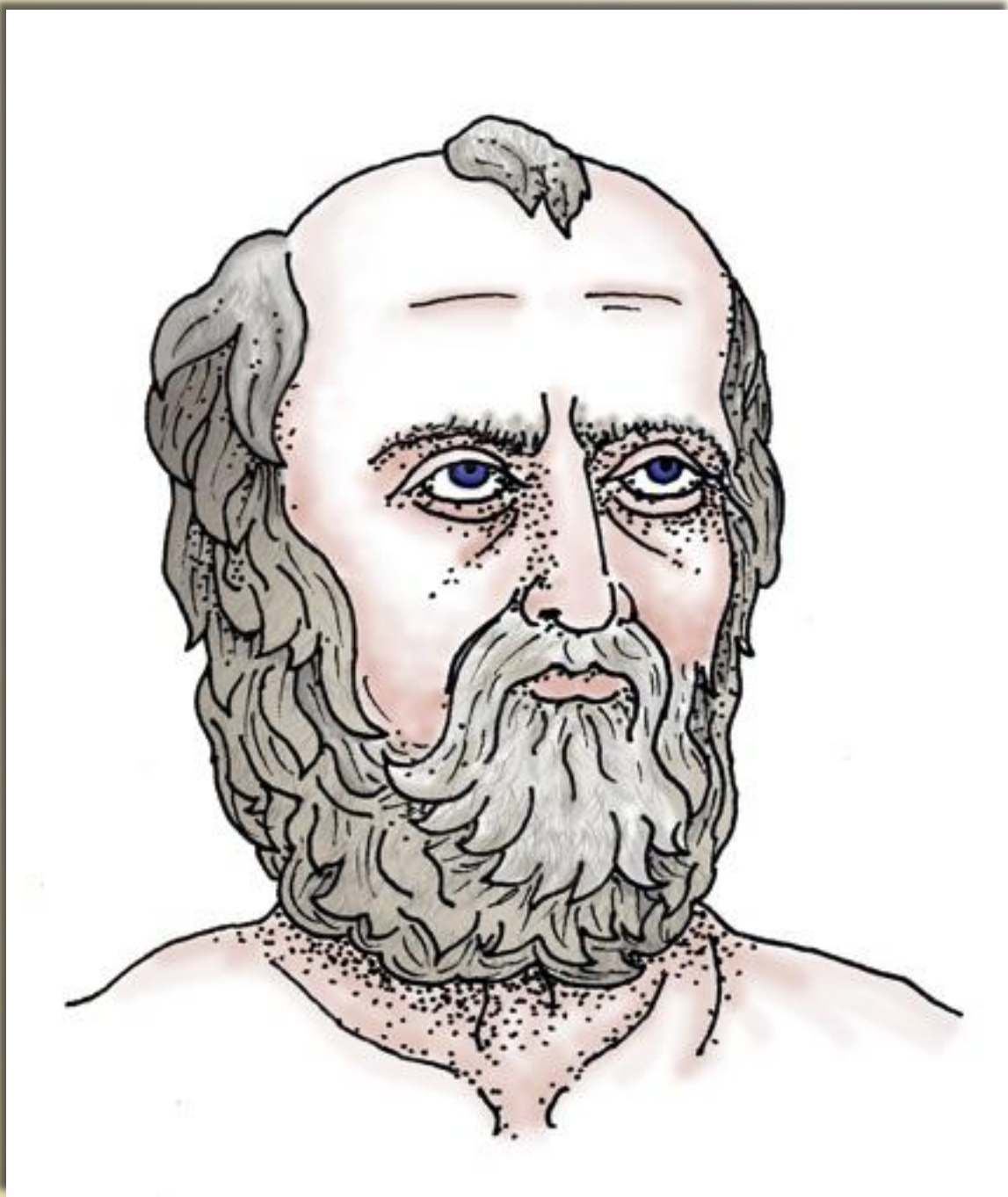
Thales of Miletus

(c. 585 B.C.)

- One of the Seven Sages
- The Olive Oil Tycoon
- Predicted an eclipse
- Civil engineer - diverted a river
- Mathematician
- Primal material is water
- Earth created from and floats upon it



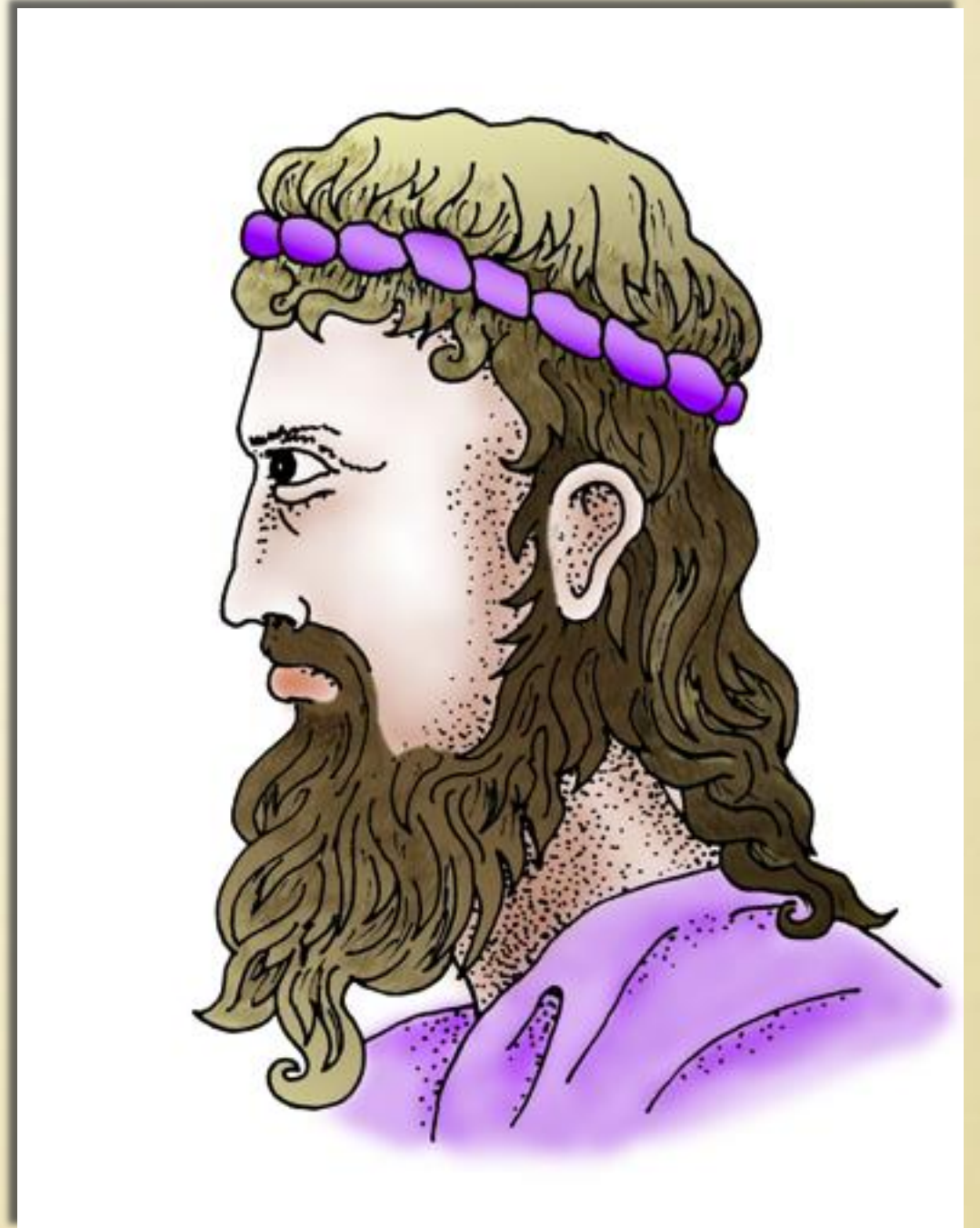
Anaximander (c. 570 B.C.)



- The Gnomon
- Primal material is The Boundless (Apeiron)
- Earth equidistant from all things, needs no support

Anaximenes (c. 550 B.C.)

- Primal material is air
- Fire is rarefied air
- Water is condensed air
- Earth is very condensed air



Parmenides of Elea

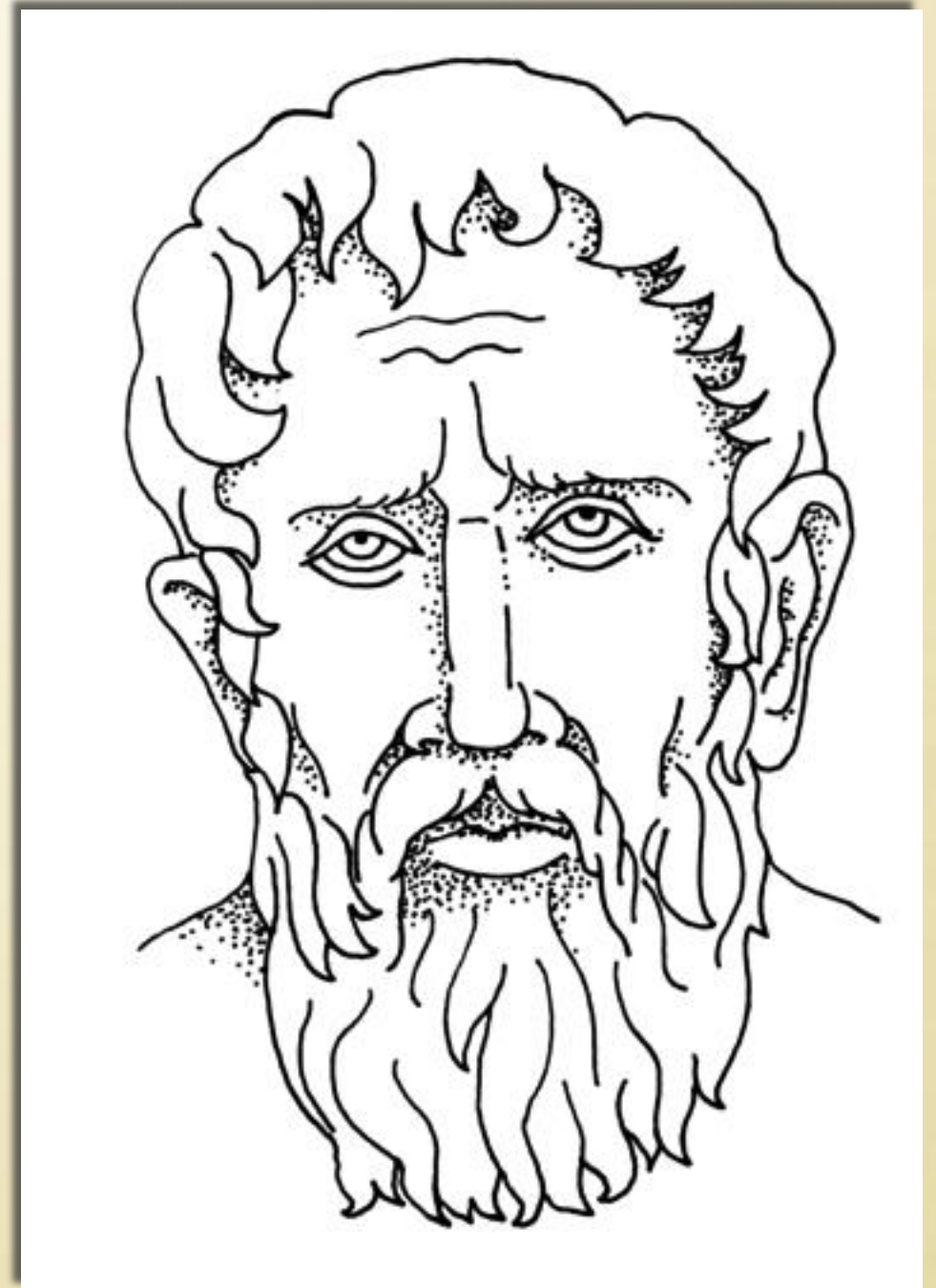
(c. 490 B.C.)



- Only two states: Being (Eon) and Non-being
- Both states are permanent
- Change is an illusion
- The senses can't be trusted; truth comes through reason alone

Zeno (c. 475 B.C.)

- Eleatic School
- Motion is a paradox (illusion of senses)
- Achilles and the Tortoise



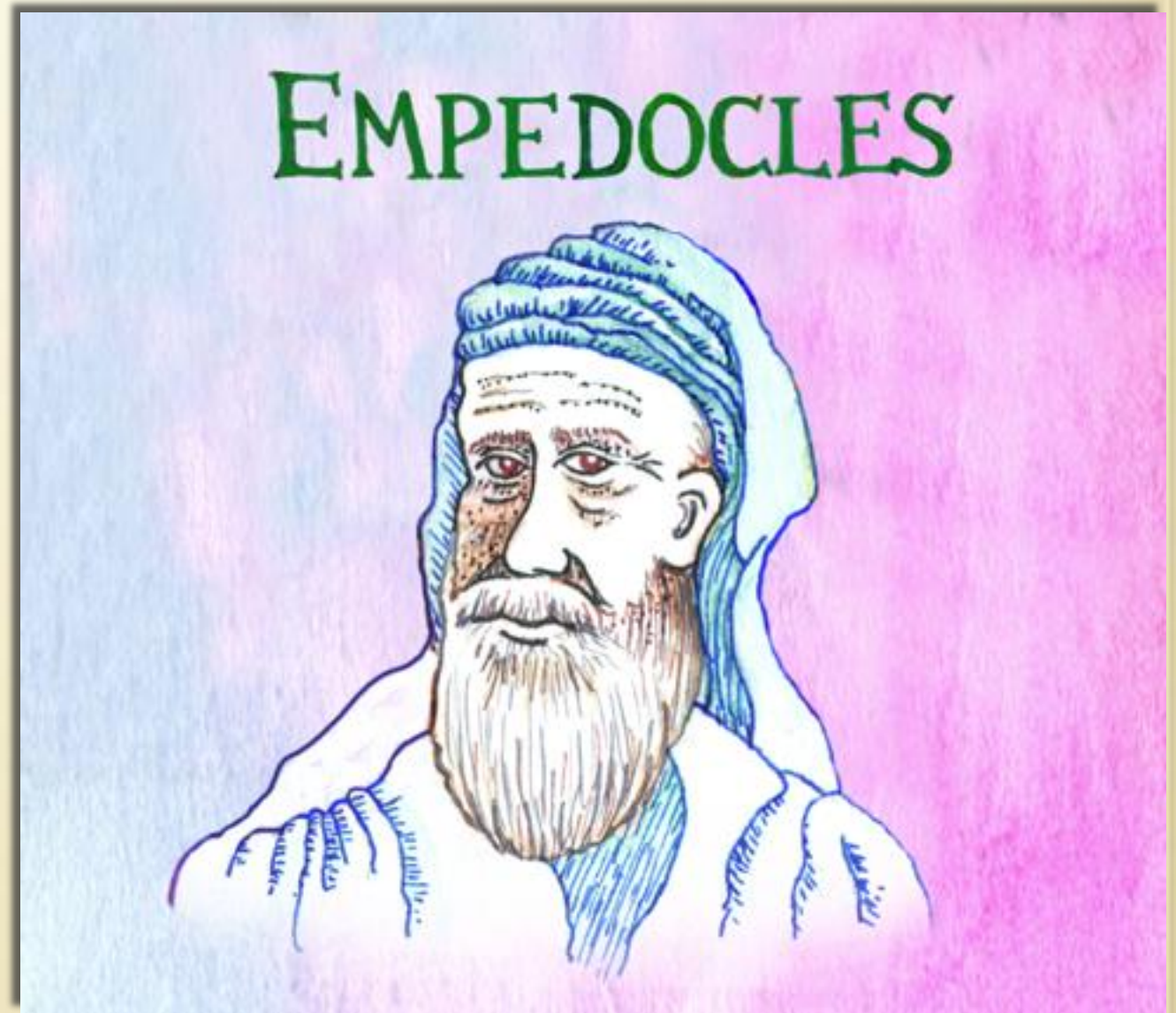
Heraclitus (c. 500 B.C.)



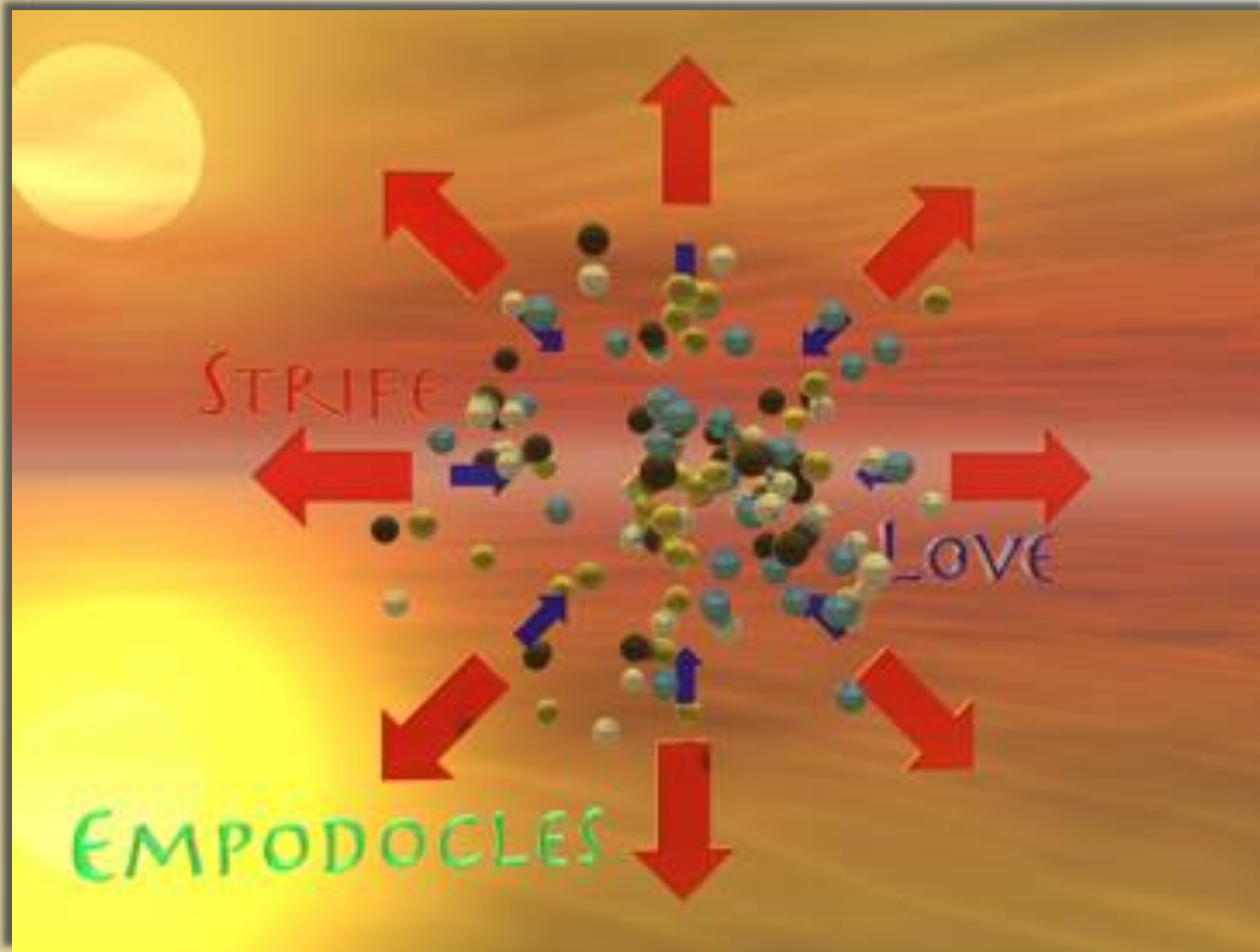
- Opposite of the Eleatic School
- Change is the only permanent thing, given structure by logos
- “You can’t step in the same river twice”
- Senses can be trusted if interpreted correctly
- World made from fire (symbol of change)
- The Weeping Philosopher
- An unfortunate ending . . .

Empedocles of Agrigento (c. 450 B.C.)

- Noble house but lived as commoner
- Made himself out to be a demigod
- Threw himself into Mt. Aetna so no body would be found to prove his mortality



Empedocles' Ideas



- The four elements (earth, water, air, fire)
- Opposing principles of love and strife
- Love is the aggregating force (brings together)
- Strife is the dispersing force (tears apart)
- Cyclic nature of universe (permanence and change)
- Elements can change from one to another during cycles

Leucippus of Abdera

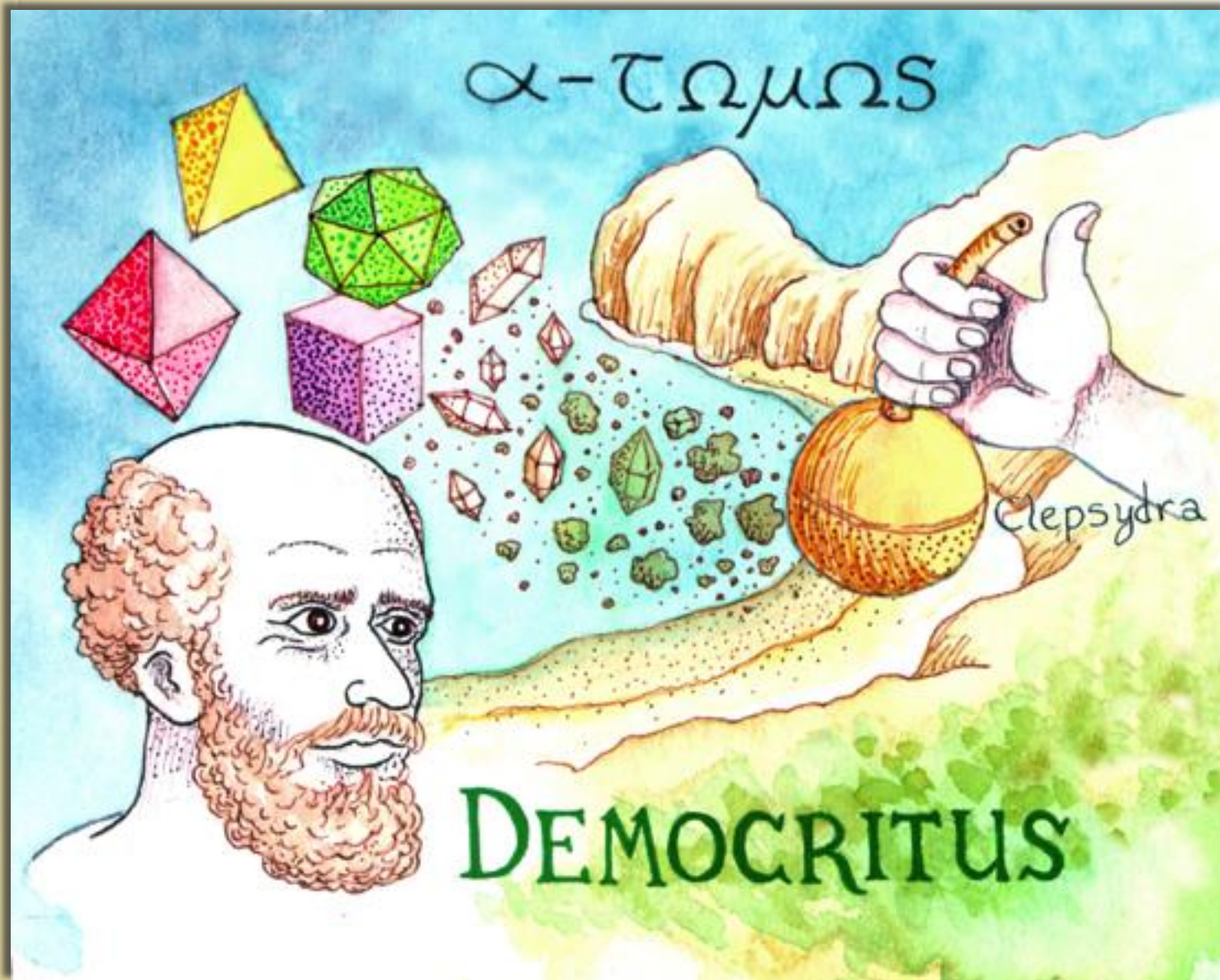
(c. 425 B.C.)

- Materials can be divided until a primal, uncuttable particle is reached: “**ATOMOS**”
- Atoms move through a void space
- Motion caused by a primeval vortex



Democritus

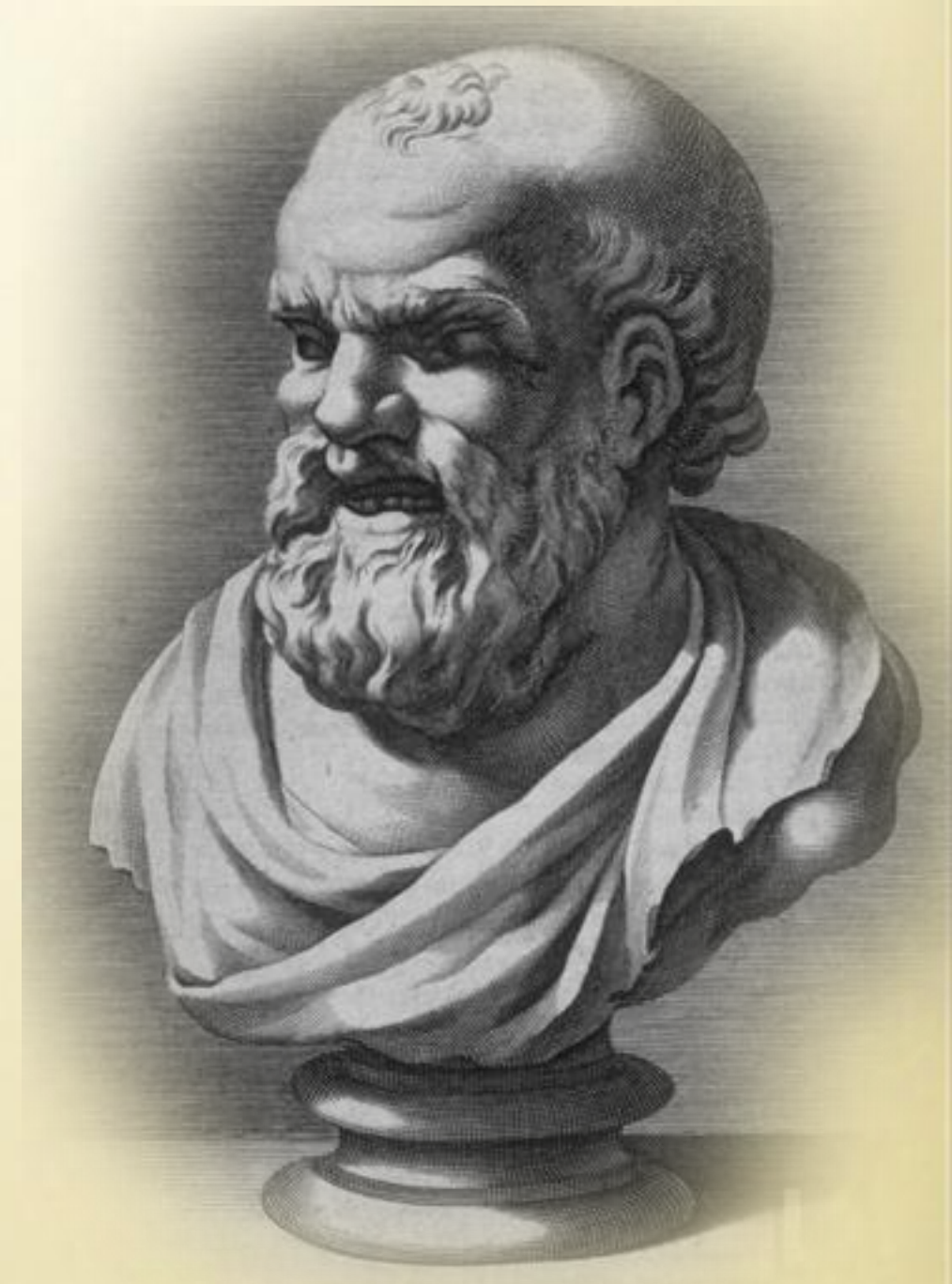
(c. 400 B.C.)



- Father welcomed Xerxes as he invaded Greece
- Democritus taught by Ostanes the Magi
- Spent inheritance of 100 talents to travel the world
- Lived as pauper upon return; known for being cheerful
- Student of Leucippus
- Wrote 70 books (including book on humor), only fragments survive

Atomic Theory (Democritus)

- Matter is composed of indivisible atoms, infinite in shape and size
- Atoms move about by “Necessity” in void space
- Atoms can latch onto each other to form materials

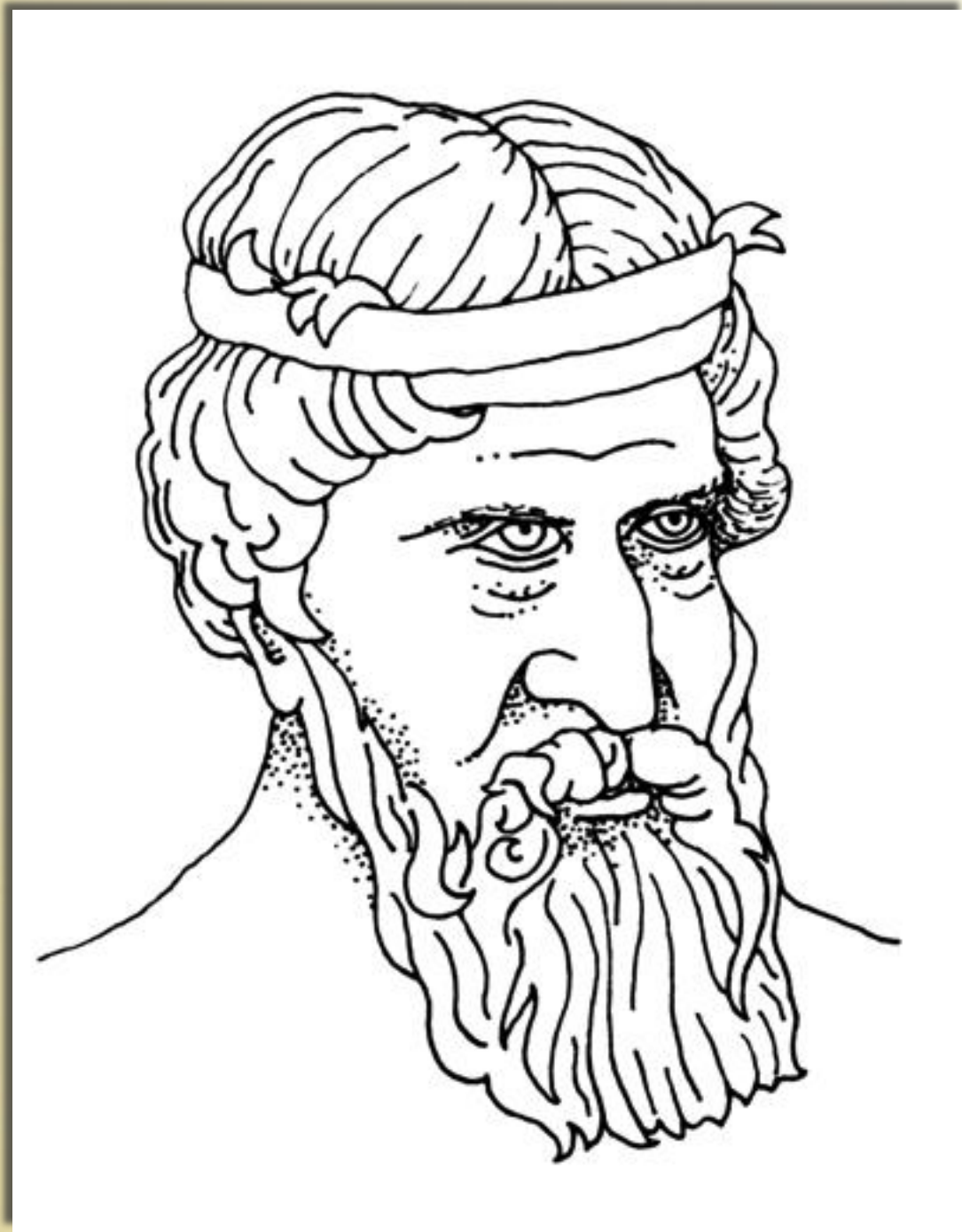


Socrates (c. 400 B.C.)

- No theories about matter
- The bust of Silenus
- The Daimon
- “Gnothi Sauton”: Know Thyself
- Become Thyself (Self-actualization)



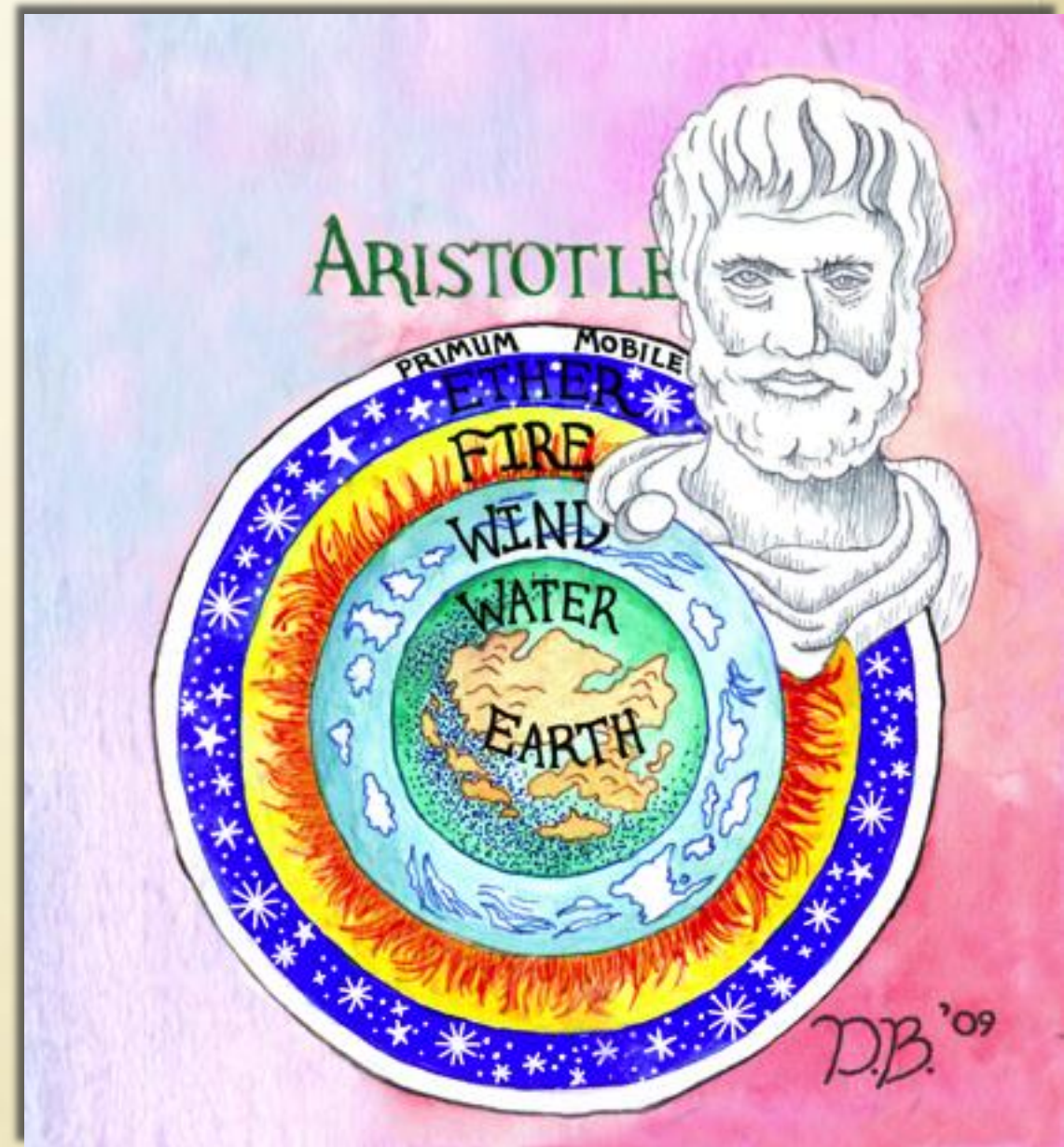
Plato (c. 375 B.C.)



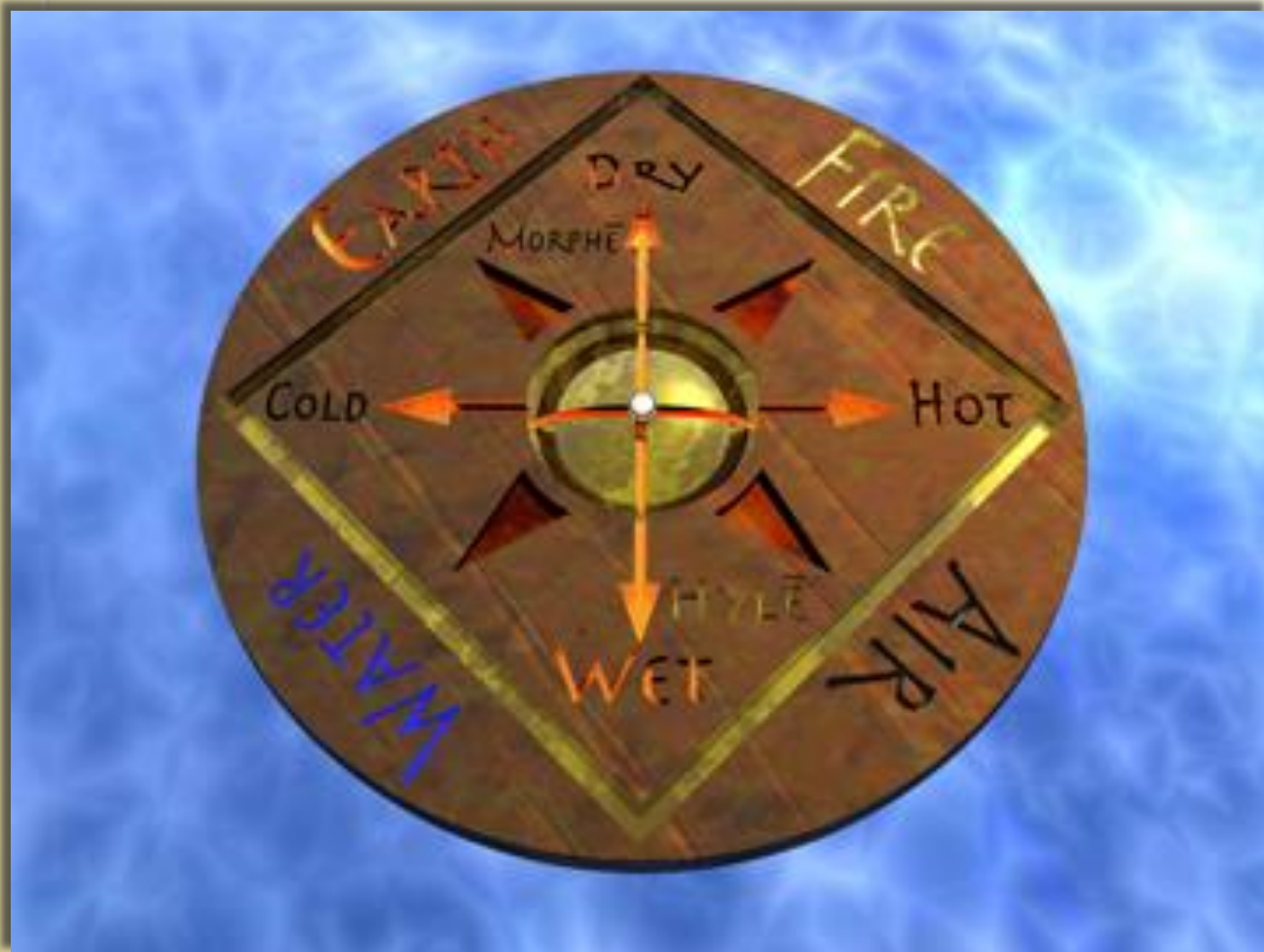
- The World of Forms
- Geometric atomism: triangles as primal shape
- Atoms shaped as perfect solids
- Fire is tetrahedron (pointy)
- Air is cube
- Water is octahedron
- Earth is dodecahedron
- Ether is sphere (heavens are spheres)

Aristotle (c. 350 B.C.)

- From Macedonia; father a counselor to Philip
- Student in Plato's School (the Lyceum) in Athens
- Diplomatic mission to Lesbos
- Tutor of Alexander the Great
- Returned to Athens and founded Peripatetic School
- Wrote many books: *Rhetoric*, *On Generation and Corruption*, etc.
- About 1/3 of works survive, mostly lecture notes



Aristotle on Materials



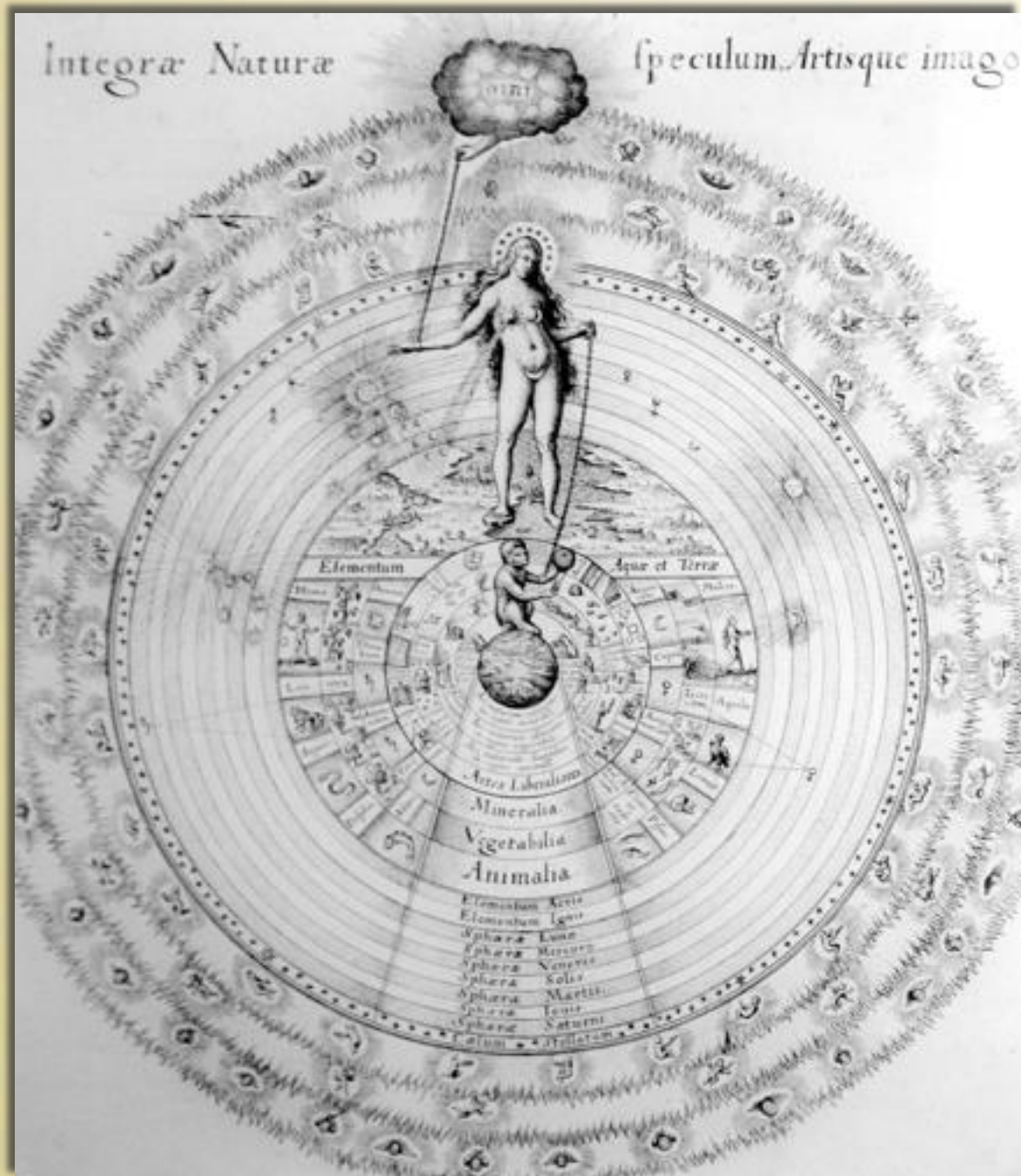
- Materials consist of a primal substance (Hyle) which takes various forms (Morphe): hylomorphism
- Two principles determine the forms: Hotness vs. coldness and dryness vs. wetness
- Fire is dry and hot, earth is dry and cold, air is wet and hot, and water is wet and cold
- Although Hyle is permanent, the Morphe can change and elements can transmute into each other

Aristotle on Motion

- Two forces control motion
- Gravity is the tendency of heavy things to sink
- Levity is the tendency of light things to rise
- Elements move because they try to regain their original positions: rocks sink in water, air bubbles rise in water, rain falls from the sky, and fire rises through air



Aristotle on the Heavens



- The elements are arranged by gravity into perfect spheres: earth, then water, air, and fire
- A fifth element (quintessence) is found in the heavens: the aether
- Heavenly bodies travel through the ether in perfect spheres
- World divided into animal, vegetable, and mineral

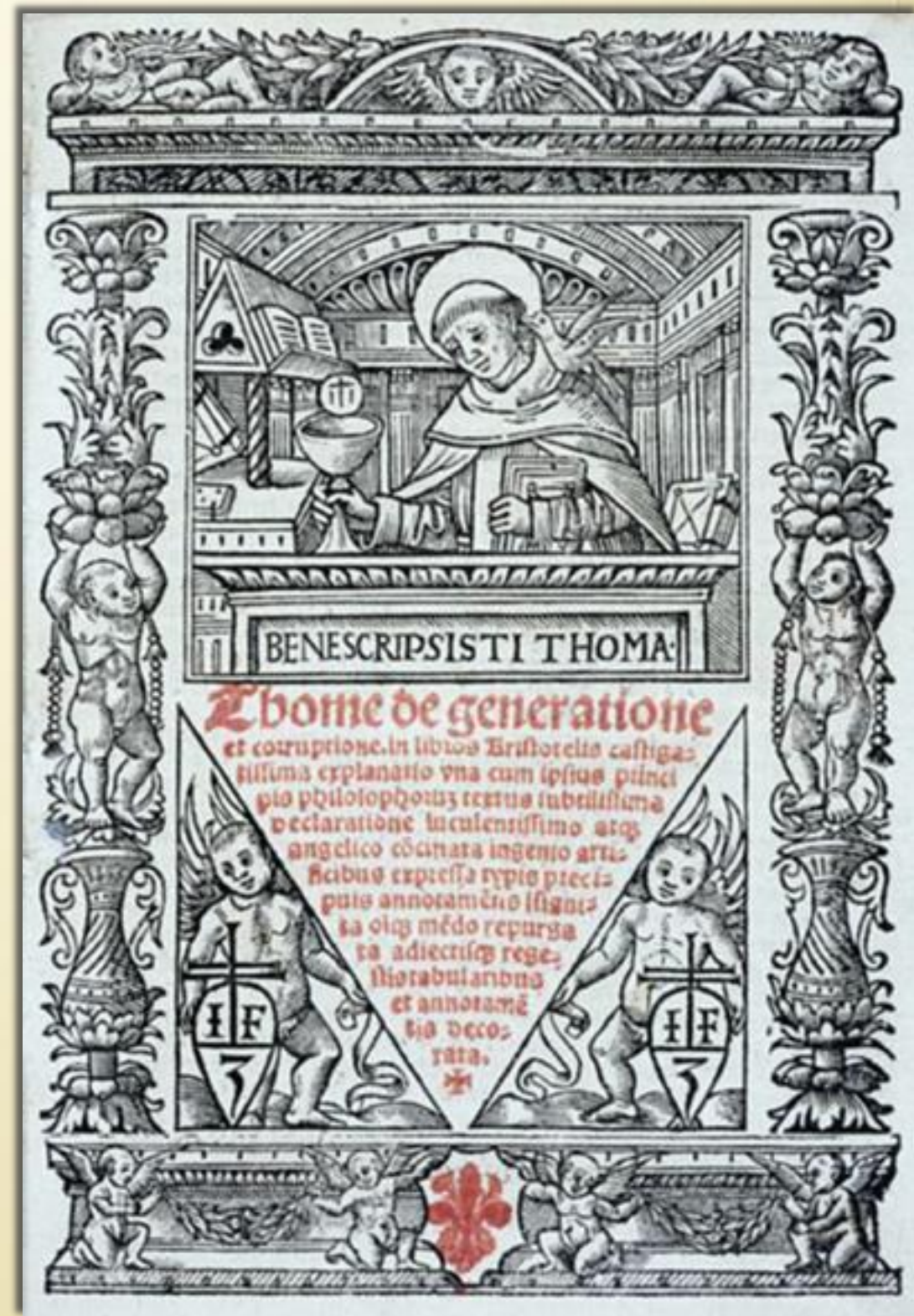
Aristotle on the Elements



- Five elements (stoichea) are continuous substances, although they do have a *natura minima* (minimal size); anything else would be cuttable
- No such thing as a void (no space between):
- Objects must travel through a medium or they would move infinitely fast
- A void is a logical impossibility (since we can speak of it, it must be something, not nothing)
- Metals are made of sulfur and mercury and can age in the earth and transmute into gold

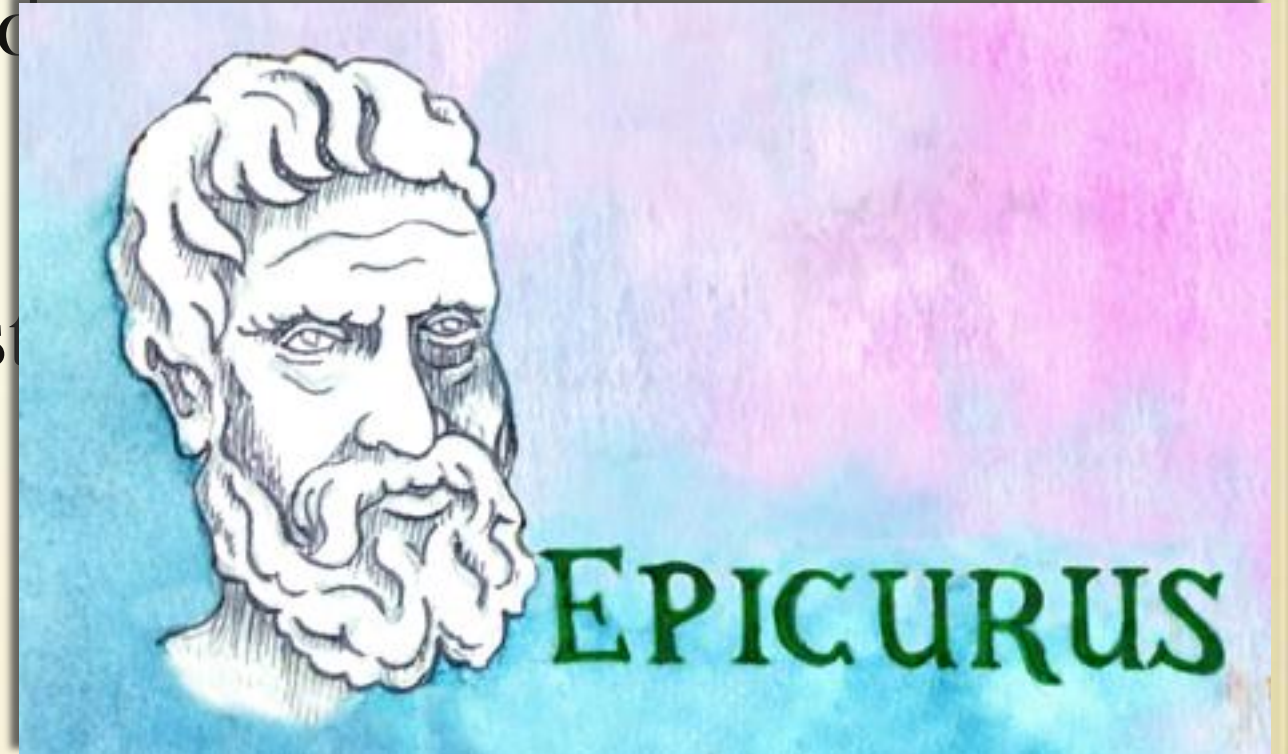
St. Thomas Aquinas

- Combined Aristotle's model of the elements with Ptolemy's model of the heavens
- This "Summa Theologica" became Catholic dogma and set back science for 500 years
- Heavens were perfect spheres with Earth at center
- Beyond the celestial sphere was the realm of God and angels, who moved the heavens like a vast machine



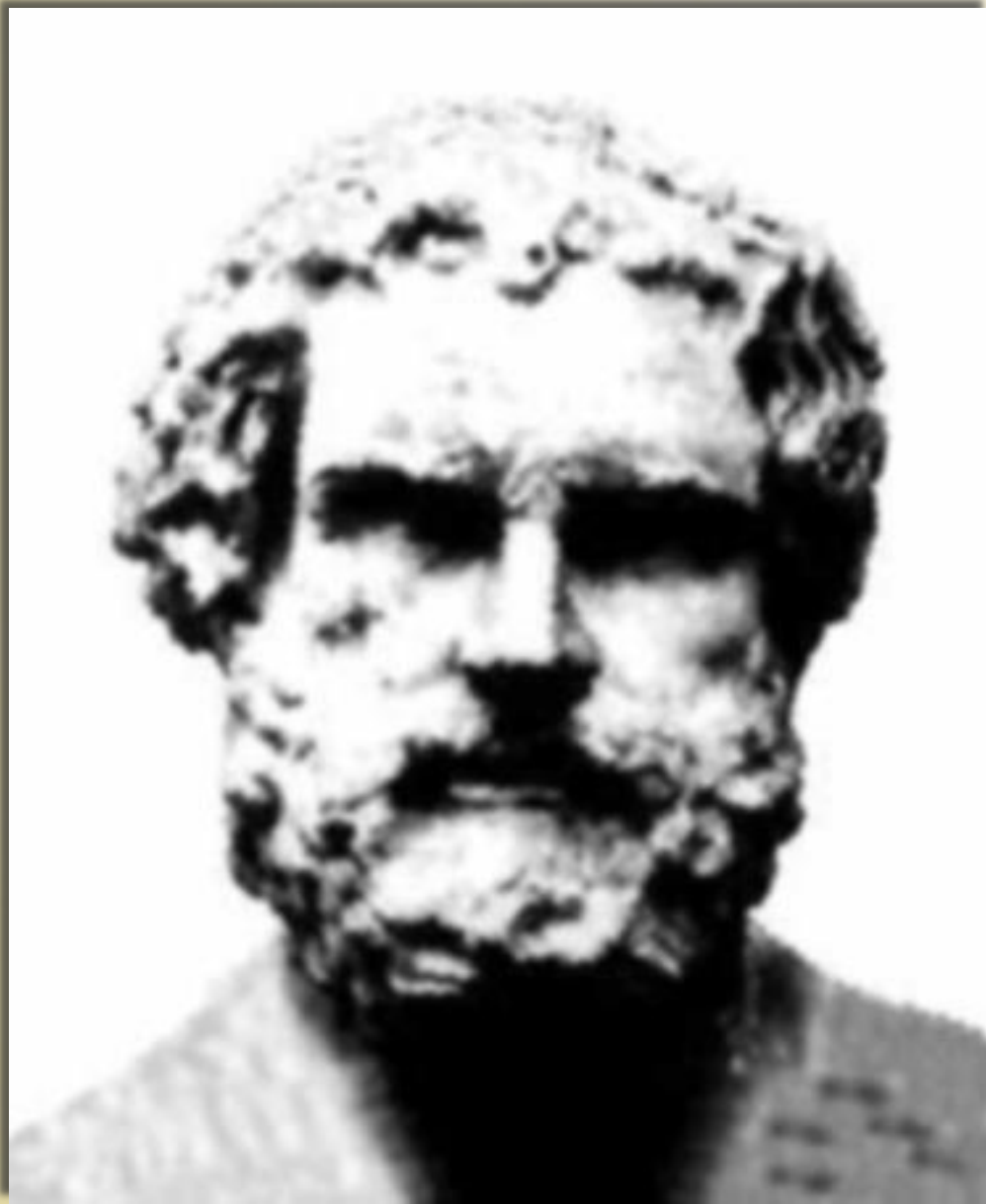
Epicurus (c. 300 B.C.)

- Atomist: “Nothing but atoms and the void”
- Elimination of pain is the highest goal
- A simple life well lived
- Associated with hedonism and condemned
- Epicurus suffered from kidney stones
- Titus Lucretius Carus: “De Rerum Natura” defends atomic theory (ring, steps, etc.)



The Four-Fold Democritus

(Christoph Lüthy)



- Father of atomic theory
- Father of Alchemy:
- *Physica et Mystica* translated by Domenico Pizzimenti in 1573
- Probably compiled by Bolus of Mendes in 2nd Century B.C. (Psuedo-Democritus)

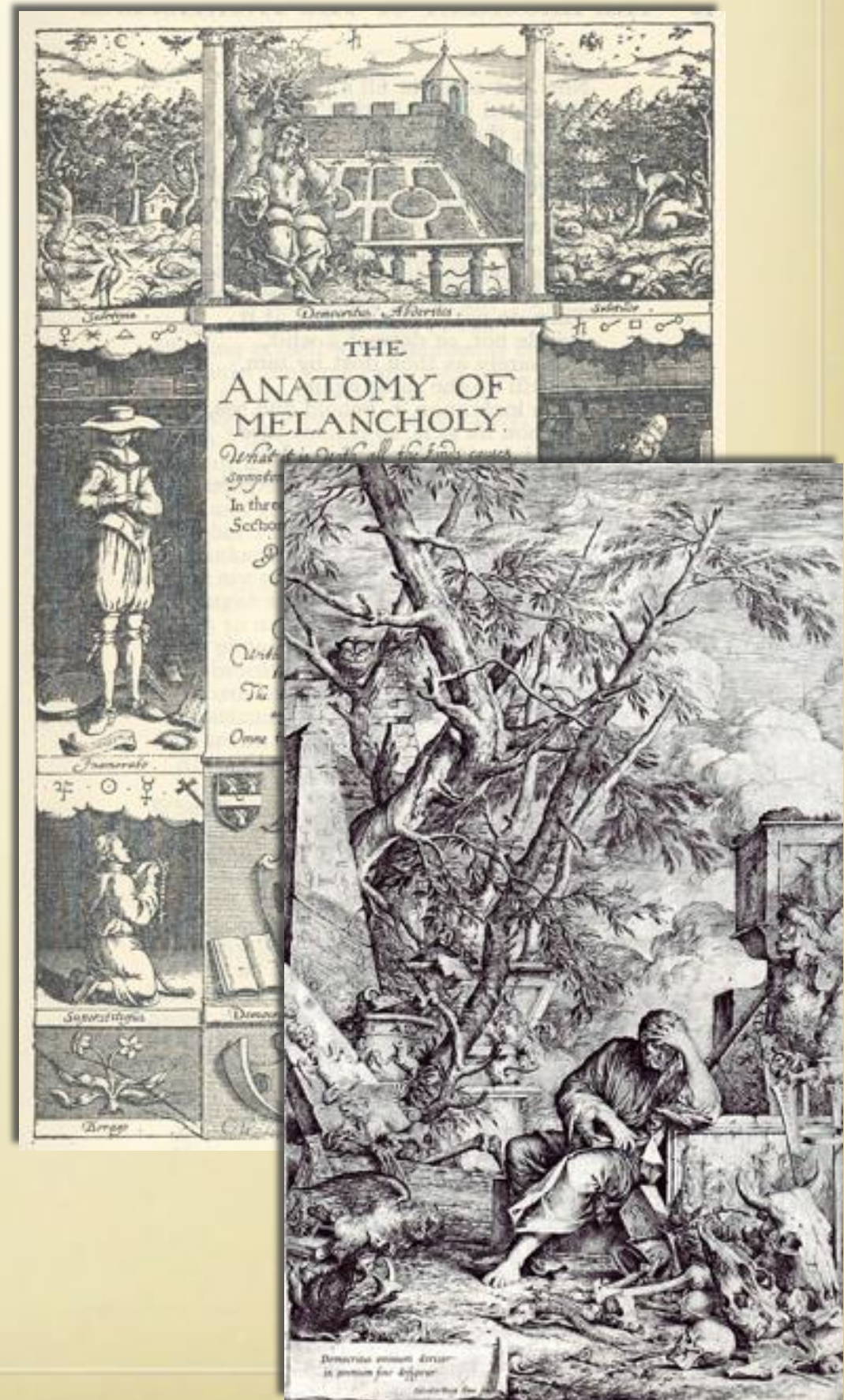
The Laughing Philosopher

- Cheerful disposition
- Life is random; you must either cry or laugh
- Heraclitus as antitype: one weeping and one laughing
- The mocker and the radical



The Tutor of Hippocrates

- Bogus letters c. 50 B.C. from a physician at Kos translated by Rinuccio Aretino in 1450
- Some letters tell of Hippocrates visiting Abdera to cure the “mad” Democritus
- Sitting under a tree with a book, surrounded by animal corpses
- Studying comparative anatomy
- The Melancholy Philosopher
- We’ll never know true Democritus



A Final Word



- We are still trying to answer the same questions
- The Greek philosophers weren't scientists (no experimental proof) but they did start us on the path toward science
- Both elements and atoms are accepted today